Controlling coherence in single photon microcavity emitters

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The exploitation of quantum physics in information processing or communication has created a demand for compact sources capable of delivering single photons that can display quantum correlations by being indistinguishable or entangled. We are developing such sources, based on single self-assembled semiconductor quantum dots. A major difficulty in obtaining indistinguishable or entangled photons stems from the fact that, during photon emission, the de-phasing of the emitting state produces random phase interruptions which destroy photon indistinguishability and entanglement. In order to restore these manifestations of quantum coherence, it is necessary to engineer photon emission through the exploitation of Cavity Quantum ElectroDynamics effects that occur when placing a quantum dot in a microcavity. By making photon emission happen faster than dephasing, coherent effects can be restored.

To this end, we develop structures in which the quantum dot is embedded in a semiconductor membrane that is etched to form a photonic crystal, with cavities formed by the introduction of periodicity defects. In this talk, we shall discuss the physical considerations for the restoration of photon indistinguishability and entanglement in the emission of a quantum dot, the constraints on cavity design, and the technological issues associated with fabrication. We shall present several devices we fabricated as solutions to these problems, and in particular we shall present microcavities capable of restoring photon indistinguishability and shall discuss our work towards cavities capable of restoring entanglement in the biexciton-exciton photon cascade.